

DOCUMENT RESUME

ED 275 766

TM 860 684

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TITLE A Developmental Analysis of Formal Reasoning in the Middle Grades.
PUB DATE [86]
NOTE 20p.; Paper presented at the Eastern Educational Research Association (Miami Beach, FL, March 1986).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Abstract Reasoning; Adolescents; *Chronological Age; Cognitive Development; *Cognitive Tests; Critical Thinking; *Formal Operations; *Instructional Program Divisions; Intermediate Grades; Junior High Schools; Piagetian Theory; Preadolescents
IDENTIFIERS Arlin Test of Formal Reasoning; *Reasoning Tests

ABSTRACT

This paper reviews some literature on the emergence of formal reasoning and reports a study of reasoning performance of 213 middle grade students in relationship to grade level and chronological age. While a number of large-scale studies have indicated that formal reasoning emerges in a regular progression across age ranges and grade levels, few researchers have analyzed the role of chronological maturation with smaller, school-related populations. Results of this investigation with such a population reveal no significant associations between chronological maturation and reasoning performance. These findings underscore the complexity of reasoning development and suggest a need for middle grades educators to avoid global generalizations regarding such development. (Author/JAZ)

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ED275766

A Developmental Analysis of Formal Reasoning

in the Middle Grades

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Running Head: A DEVELOPMENTAL ANALYSIS OF FORMAL REASONING

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A Developmental Analysis of Formal Reasoning

Abstract

This investigation analyzes the performance of 213 middle grades students on a test of formal reasoning in relationship to grade level and chronological age. While a number of large-scale studies have indicated that formal reasoning emerges in a regular progression across age ranges and grade levels, few researchers have analyzed the role of chronological maturation with smaller, school-related populations. Results of this investigation with such a population reveal no significant associations between chronological maturation and reasoning performance. These findings underscore the complexity of reasoning development and suggest a need for middle grades educators to avoid global generalizations regarding such development.

A Developmental Analysis of Formal Reasoning

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in the Middle Grades

In The Growth of Logical Thinking from Childhood to Adolescence (1958), Piaget and Inhelder proposed that formal operations emerge through a series of stages during the developmental period from 12 - 15 years of age. Since that publication, the acquisition of formal reasoning has been the subject of a substantial body of research and discussion. Investigations conducted with large groups of students suggest that formal operations emerge in a regular progression that is largely maturational. Few studies, however, have directly investigated the linkage between chronological age and formal reasoning. The nature of this linkage may have important implications for teachers in the middle grades as a number of educators have proposed curricular modifications based on a maturational theory. This paper reviews a portion of the literature on the emergence of formal reasoning and reports an investigation of the reasoning performance of middle school students as it relates to chronological age and grade level.

Review of the Literature

The onset of formal reasoning

A number of investigations have attempted to describe the onset of formal reasoning. One of the first large-scale international studies was Karplus (1977). In this project, 3600 students ages 13 - 15 from 7 different countries completed proportional reasoning tasks. Results indicated that about one-fourth of all subjects gave fully formal "ratio" responses with

most subjects in transitional categories. Differences in achievement among countries were not nearly as significant as differences among socioeconomic and gender groups within countries. Karplus concluded that developing reasoning patterns should be emphasized in school programs everywhere.

In order to assess performance on a wider range of tasks across a wider age range, Shayer, Kuchemann, and Wylam (1976) developed three structured interview activities and validated them with original interview tasks. As reported in Table One, the results of their assessment of 10,000 students ages 9 - 14 in Great Britain indicated that only one-fifth of their subjects demonstrated formal thought. When presented by age cluster, results suggest that formal operations emerge in a regular progression during the period from 11 through 18 years of age.

Arlin (1984) reports a similar progression by grade level in results obtained from her normative sample in the development of the Arlin Test of Formal Reasoning (Table One).

Insert Table 1 about here

In order to reduce some the complexity of these larger scale studies and to explore intraindividual consistency in formal operational thinking, Martorano (1977) administered 10 different formal tasks to 80 female students in grades 6, 8, 10, and 12. The data from her investigation provided an overview of development at these grade levels that spans a wider range of formal tasks and reflects controls for gender and intelligence differences. Among sixth graders, 20.5% "passed" each task; 27%

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of the eighth graders "passed;" 52% of tenth graders; and 61% of twelfth graders (Table One).

A review of a wider sample of these studies (Strahan, 1983) suggested that regardless of tasks and methodologies employed, one-third (or fewer) of eighth graders assessed demonstrated formal reasoning. Most of the studies reviewed compared students' reasoning by grade level or age interval. When considered in this fashion, formal reasoning appears to emerge in a regular progression related to chronological maturation. In one of the few studies to specifically analyze the role of chronological age, Sherwood and Strahan (1985) found that chronological age accounted for 34.6% of the variation in scores on the Arlin Test of Formal Reasoning. Their study was conducted with a gifted population, however, and no similar investigation of a normal population has been reported.

Formal reasoning and curricula

Growing recognition of the transitional nature of early adolescent thinking has resulted in several analyses of the reasoning demands of school curricula for this age group.

Elkind (1980) proposed a "developmental analysis" of secondary curricular content. He suggested that it is very difficult for educators to understand the reasoning processes of their students because teachers' thinking about their content subjects has become "automatic." A detailed exploration of the logical substructure of selected academic tasks revealed that much of the content of middle grades curricula is formal in nature. For example, "the study of geography and of social history, which is often taught in the seventh grade, presupposes

that students hold abstract conceptions of space and time (p. 22)." These conceptions require a high degree of formal operations. Elkind illustrated other examples of abstract content in math, science, language arts, and health. He concluded that "the material we present to young people may be difficult in ways we do not and cannot appreciate and suggests that teachers attempt to provide a better match between the nature of tasks and the developmental levels of students (p. 24).

Adelson (1983) reported an investigation of the development of political cognition in students from grades 5 - 12. He further delineated the concreteness of early adolescent thinking and the complexity of such concepts as government, democracy, education, freedom of speech and justice - concepts which teachers take for granted (p. 162). He, too, suggested that teachers attempt to understand the cognitive limitations of their students and encourage "small leaps in comprehension (p. 162)."

Bart (1983) studied the performance of students ages 13 - 19 on 7 formal operational tasks. Like Adelson, he noted the effect of chronological age on performance but also emphasized the linkage between formal reasoning skills and school achievement, suggesting that such skills are prerequisites for success in secondary science and math (p. 882).

Arlin (1984) suggested a series of linkages between the development of formal reasoning and success in economics, ecology, mathematics, biology, chemistry, literature and art (p. 10).

A number of educators share these concerns regarding the

relationship between students' levels of reasoning and the expectations of the curriculum. In a review of related studies, Strahan and Toenfer (1984) suggested that cognitive "readiness" is a critical factor for teachers in all subject areas. Their analysis of investigations in reasoning development suggested that teachers must consider the nature of the academic task when assessing students' reasoning strategies and build abstractions from concrete experiences.

Questions raised

This brief review of the literature on the emergence of formal thinking supports the need for middle grades educators to learn more about the reasoning development of their students. The apparently low incidence of formal reasoning among students icoupled with the seemingly abstract demands of many curricula suggests that teachers to develop more efficient "matches" between tasks and performance.

Beyond this general conclusion, a number of critical questions surface. One such question is predictability of patterns of performance among students across grade levels. When large groups are profiled by mean grade level scores, regular patterns are reported. Few investigations have explored the distribution patterns among smaller groups. Teachers may wish to know how much variation exists in actual classes. A second question is the role of chronological age in the emergence of formal reasoning. Few of the studies reported analyze the role of grade level or chronological age beyond reporting frequencies or mean scores. The critical question of whether grade level or age are significantly associated with reasoning performance in

smaller samples remains largely unexplored.

An Investigation of Reasoning Performance Related to Age

Purpose

The purpose of this study was to examine how grade level and chronological age are related to the performance of early adolescents on a test of formal reasoning. The research hypotheses tested were

1) Grade level is significantly associated with performance on a test of formal reasoning in the middle grades.

2) Chronological age is significantly associated with performance on a test of formal reasoning in the middle grades.

Method

The study included 213 students in grades 6, 7, and 8 from randomly assigned middle school classrooms in a small city school district in North Carolina. Table Two provides an overview of the characteristics of these students.

Insert Table 2 about here

As the scores in Table Two indicate, the sample group slightly exceeded grade level expectations on the most recent achievement tests. The composition of this sample by race and gender approximates the national population of middle grades students.

The Arlin Test of Formal Reasoning (ATFR) was administered to this group to provide a measure of reasoning performance. Developed as a pencil-and-paper approximation of Piagetian interviews, this 32 item instrument provided a total score that estimated students' level of reasoning (concrete, high concrete,

transitional, low formal, high formal). Results of test analyses have indicated high construct validity with interview measures, test-retest reliabilities ranging from .76 to .89, and Hoyt estimates of reliability from .71 to .89 (Arlin, 1982).

From birthdays recorded on the answer sheets, researchers calculated students' ages in months. Analysis of Variance and Analysis of Regression Procedures then provided a means to examine the role of grade level and chronological age in relation to the scores on the ATFR.

Results

Tables Three and Four report comparisons between the scores of the sample group and the scores of Arlin's (1984) normative group. As indicated in Table Three, mean scores for all three grade level groups in the sample fell significantly below those reported for the normative group. Frequency distributions (Table Four) indicate lower percentages of students in the formal stages in the sample group at all three grade levels. None of the students in the sample group reached the "high formal" level.

Insert Tables 3 and 4 about here

These tables indicate that the seventh graders in the sample group performed about as well as the eighth graders. In fact, a higher percentage of seventh graders (15.4) scored at a formal level than did the eighth graders (5.1).

In order to obtain a more precise assessment of the relationship between grade level and score, an Analysis of Variance between grade levels and levels of reasoning was

computed (Table 5).

Insert Table 5 about here

Results indicate that grade level was not a significant main effect in determining level of reasoning.

As a final analysis of the role of chronological age, a linear regression was computed. The resulting correlation (-0.048) indicates that age is not significantly associated with scores on the ATFR. Similar results (0.15, -0.014) were obtained for grade level and gender differences.

Discussion

The results of this investigation do not support the hypotheses tested. In this sample, neither grade level or chronological age is significantly associated with performance on a test of formal reasoning.

Differences between the sample group and the normative group may account for some of the lack of association of grade level and chronological age with reasoning development. While this sample group slightly exceeded grade level expectations on the most recent achievement tests, scores on the ATFR were significantly lower than those of the normative group at each grade level. Moreover, many sixth and seventh graders scored as well as eighth graders. Compounding characteristics of this particular sample may thus account for some of the absence of association. Even so, these limitations cannot fully account for the lack of association between chronological age or grade level and performance on the ATFR. These results suggest that while

there may be a regular progression in the emergence of formal reasoning in large populations, smaller samples may reveal no such progression.

Given these findings, middle grade educators should try to avoid global assumptions regarding differences in grade level groups. Students in an eighth grade class may not reason any more abstractly than sixth or seventh graders. The absence of age as a factor in this investigation dramatically underscores the importance of individual differences when analyzing reasoning performance. Neither age nor grade level were useful factors in predicting performance for this sample.

The results of this investigation indicate a need for intensive analysis of the role of scholastic aptitude as it relates to formal reasoning. Since Sherwood and Strahan (1985) found chronological age to be a significant factor in a gifted population, it may well be that age and aptitude differences interact in their effects on reasoning development. This question is being investigated in a follow-up analysis of relationships between scores on the ATFR, achievement tests, and scholastic aptitude tests with this same sample population.

In summary, these findings underscore the complexities inherent in the transition from concrete to formal reasoning. This transition may not occur in the regular progression suggested by other analyses. Such is especially the case for smaller, school-based populations, classroom groups, and individuals. In reporting his findings, Adelson (1983) noted that

Because of the biological and social changes taking place and because it is an age of great cognitive change, this group seems particularly difficult to reach. The youngster often seems to flip-flop in terms of intellectual level - at one moment concrete and rather primitive, at another moment capable of abstract and advanced thought (p. 161).

It may well be that formal reasoning emerges in a series of "flip-flops," experiments with new modes of thought new powers of abstraction. Such reasoning is not only difficult to assess but difficult to enrich as well. If teachers are to understand the reasoning of their students, the information gained from instruments such as the ATFR may provide a useful beginning. The complexities of reasoning apparent in this investigation suggest that teachers must also consider the intricate nature of reasoning development and generate a wide variety of informal procedures for assessing and extending such development on a more individualized basis.

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Table 1

Percentage of Students Demonstrating Formal Operations

Shayer & others (1976)			Arlin (1984)		Martorano (1976)	
Age (years)	Formal Onset	Formal Mature	Grade	Low Formal	High Formal	Average of Formal Tasks
<u>10</u>	1					
<u>11</u>	5					
<u>12</u>	12		<u>6</u>	9	1	20.5
<u>13</u>	14	6	<u>7</u>	17	3	
<u>14</u>	15	9	<u>8</u>	27	7	27.0
<u>15</u>	19	13	<u>9</u>	31	6	
<u>16</u>	17	13	<u>10</u>	37	13	52.0
<u>17</u>	19	12	<u>11</u>	33	17	
<u>18</u>	15	19	<u>12</u>	39	20	61.0

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Table 2

Description of Sample Population

	*Reading Achievement			*Math Achievement	
	N	MEAN	SD	MEAN	SD
<u>sixth grade</u>	67	503 (GE=6.8)	71.7	494 (GE=6.7)	58.6
<u>seventh grade</u>	68	547 (GE=8.6)	55.3	532 (GE=8.0)	53.8
<u>eighth grade</u>	78	559 (GE=9.0)	63.7	560.4 (GE=8.9)	54.5

*California Achievement Test, scaled scores (GE = grade equivalent)

Table 3

A Comparison of Mean Scores by Grade Level

<u>Grade</u>	<u>Sample group</u>			<u>N</u>	<u>Arlin</u>		<u>Difference</u>	
	<u>N</u>	<u>mean</u>	<u>SD</u>		<u>mean</u>	<u>SD</u>	<u>t-value</u>	
6	67	9.73	3.55	518	12.06	3.74	2.33	*4.85
7	68	11.13	3.99	499	13.24	4.14	2.11	*3.91
8	78	11.17	3.86	467	15.69	4.47	4.52	*8.37

*exceeds 3.29 (critical value of t at 120+ df, $p = .001$)

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Table 4

Percentage of Students Within Each Cognitive Level: A Comparison
of Research and Normative Population (in parentheses) (Arlin,
1984)

Arlin Stages	Grade 6		Grade 7		Grade 8	
Concrete	26.9%	(22%)	13.2%	(14%)	19.2%	(8%)
High Concrete	64.2%	(58%)	66.2%	(51%)	60.3%	(42%)
Transitional	7.5%	(10%)	14.7%	(15%)	15.4%	(16%)
Low Formal	1.5%	(9%)	15.4%	(17%)	5.1%	(27%)
High Formal		(1%)		(3%)		(7%)

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Table 5

ANOVA -- Grade Level X Level of Reasoning

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance
Main Effect					
GRADE	6.04	2	3.02	1.004	0.368